

**Position specific differences in the anthropometric characteristics of elite European Super
League rugby players**

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Abstract

Rugby league is a collision sport which traditionally adopts a large emphasis on lean muscle mass. Currently there is limited research on the anthropometry of European Super League players. The aim of this study was to assess body-composition using Dual X-ray Absorptiometry (DXA) scans to identify the typical profile of elite rugby league players. One hundred and twelve players from five different clubs competing in the European Super League were recruited for the study. DXA scans were performed and the total-mass, lean-mass, fat-mass and percentage body-fat was reported for each positional group. For the Fullback and Wingers, Centres, Half Backs, Hookers, Props and Back Row Forwards the mean (SD) body fat % was 13 (2.1), 13 (2.4), 12 (3.4), 15 (3.9), 16 (4.3) and 15 (2.1)%, respectively, and total mass was 86 (8.2), 91 (6.6), 81 (8), 84 (9.5) 102 (8.5) and 93 (5.5) kg, respectively. Despite small to very large inter positional differences in all anthropometric variables (effect sizes = -0.08 to 2.56), particularly between the Prop and the other playing positions, there was large intra-position variation in body-fat, lean-mass and total-mass making a standardized position specific profile difficult to establish. When used with other key performance indicators, these data provide the first multi-team anthropometric profile of elite Super League players that can be used to guide individualized training and nutrition practices current and aspiring athletes.

Keywords: Rugby, Pre-Season, DXA, Body-composition, Physiology, Nutrition

1 **Introduction**

2 Rugby league is an intermittent team sport played in several countries worldwide. Normal game duration is
 3 80 minutes, comprised of 2 x 40 min halves that are separated by a 10-minute rest interval. During a game
 4 players perform complex tasks involving frequent bouts of high-intensity activity (e.g. sprinting, side
 5 stepping, passing and collisions) separated by acute bouts of low intensity activities (e.g. standing, walking
 6 and jogging) (Austin & Kelly, 2013; Gabbett et al., 2014; Twist et al., 2014). Activities performed during a
 7 match vary depending on playing position, which are typically categorized as forwards (prop, back row),
 8 adjustables (halfback, standoff, hooker) and outside backs (fullback, winger, centre). While outside backs
 9 (~7,000 m) cover greater absolute distances than adjustables (~6,000 m) and forwards (~4,000 m) (Waldron,
 10 Twist, Highton, Worsfold, & Daniels, 2011; Gabbett, Jenkins, & Abernethy, 2012), total distance covered
 11 relative to match time ($\text{m}\cdot\text{min}^{-1}$) is similar between positions (~90-95 $\text{m}\cdot\text{min}^{-1}$) (Gabbett et al., 2012; Waldron
 12 et al., 2011). On average, forwards are also involved in around one physical collision (tackle or being tackled)
 13 with the opposition per minute of playing time, whereas this occurs less frequently for outside backs (~0.3
 14 min^{-1}) and adjustables (~0.6 min^{-1}) respectively (Gabbett et al., 2012; Twist, Waldron, Highton, Burt, &
 15 Daniels, 2012).

16 It is well known that the various playing positions in rugby league require unique physical qualities based on
 17 their specific roles (Gabbett & Seibold, 2013; Meir, Newton, Curtis, Fardell, & Butler, 2001; 1996). For
 18 example, props are required to carry the ball forward into the defence, make distance and tire opposing
 19 defenders, meaning coaches prefer these players to have high total body and lean mass. Conversely, wingers
 20 require acceleration and speed qualities to evade defenders and, as such, are often lighter than other positions
 21 within the team (Cheng et al., 2013). These differences in anthropometric characteristics are therefore
 22 observed between positional groups in both elite (Lundy, O'Connor, Pelly, & Caterson, 2006; Meir et al.,
 23 2001; 1996) and sub-elite (Gabbett, Kelly, & Pezet, 2008) players. Low skinfold thickness (as a proxy
 24 marker of body fat) is one of the most important discriminators between selection and non-selection in senior
 25 elite NRL players (Gabbett, 2009; Gabbett, Jenkins, & Abernethy, 2011b) and differentiates between higher
 26 and lower playing standards (Gabbett, Jenkins, & Abernethy, 2011c; Till et al., 2011). Higher skinfold

1 thicknesses and lower estimated lean mass are also related to poorer tackling ability (Gabbett, Jenkins, &
2 Abernethy, 2011a). In juniors, anthropometric data have been used to predict player selection in the UK
3 highlighting the importance of body composition to talent development (Till, Copley, O'Hara, Chapman, &
4 Cooke, 2010).

5 Despite the apparent importance of body composition to success in rugby league, to date there are limited
6 studies reporting these measures in elite European Super League players from a number of teams. Indeed,
7 with coaches adopting different styles of play, player type preferences and tactics during matches, it is
8 important to assess players from more than one team (Georgeson, Weeks, McLellan, & Beck, 2012; Harley,
9 Hind, & O'Hara J, 2011). Additionally, within one club there may be a limited number of players for each
10 playing position and so a typical body composition profile is hard to establish. Furthermore, many of the
11 previous studies assessing body composition in rugby league players have only utilised skinfold measures
12 and predictive equations, which have obvious limitations (Doran et al., 2014; Reilly, Wilson, & Durnin,
13 1995). While previous studies have used DXA scan technology to assess the body composition in elite rugby
14 league players, these have not differentiated between positional groups (Harley et al., 2011; Kelly et al.,
15 2012), or have been on Australian NRL players (Georgeson et al., 2012). A profile of body composition
16 characteristics in a large group of players from a variety of European Super League teams would therefore be
17 useful to enable position specific anthropometric characteristics to be established. Such data might then be
18 used for talent identification and to assist in individual training and nutrition practices. Accordingly, the aim
19 of this study was to assess the anthropometric data of elite rugby league players taken from several European
20 Super League teams to identify the typical positional profiles.

21

22

1 **Methods**

2 **Participants and study design**

3 One hundred and twelve elite rugby league players currently playing in the European Super League
4 volunteered for this study. Data were collected on the first team squad members of five teams. Players were
5 categorized into six positional groups based on where they played at club and international standard, these
6 being: Fullbacks and Wingers (24), Centres (10), Halfbacks (18), Hookers (10), Props (24), and Back Row
7 Forwards (26). If players played in multiple positions they were asked to self-select their predominant
8 position. All testing took place during the final weeks of pre-season or in the first two weeks of the season in
9 accordance with the availability of the selected clubs. All players from the same club were tested on the
10 same day. The local ethics committee of Liverpool John Moores University granted ethical approval for the
11 study.

12 Players attended the laboratory between 07.00-10.00 in a fasted and hydrated condition having refrained
13 from exercise in the previous 12 h. Players were weighed wearing shorts only and height was recorded using
14 a dual height/body mass stadiometer (SECA, Birmingham, UK) to the nearest 0.1 kg and 0.5 cm respectively.
15 Mean coefficient of variation for height and body mass was 0.23% and 0.00%, respectively. A whole body
16 Dual energy X-ray absorptiometry (DXA) scan was then performed for the assessment of body composition.

17 **DXA assessment**

18 All players underwent a whole body fan beam DXA measurement scan (Hologic QDR Series, Discovery A,
19 Bedford, MA, USA) analysed using QDR for Windows software version 12.4:3. The effective radiation dose
20 was approximately 0.01 mSv per person. Removal of all jewellery and metal objects was ensured before
21 each scan. Scans were performed and analysed by the same trained operator, according to standard in-house
22 protocols to achieve high precision scans. Prior to each set of data acquisitions, calibration was carried out
23 using an anthropometric spine and step phantom with a subsequent radiographic uniformity scan following
24 the Hologic guidelines. The coefficient of variation (CV) and absolute technical error of measurement (TEM)
25 has been published previously (Egan et al., 2006) whilst using this specific DXA scanner to show the test-
26 retest reliability. In brief, CV and TEM for whole body fat mass, lean mass and percent body fat was as

follows: 1.9% and 0.37 kg, 1.0% and 0.44 kg and 1.9% and 0.41%, respectively. Further, regional reliability estimates are also reported: upper limb fat mass (2.8%, 0.06kg), lower limb fat mass (2%, 0.15 kg), trunk fat mass (1.9%, 0.42kg), upper limb lean mass (4.5%, 0.05 kg), lower limb lean mass (2.8%, 0.11kg), trunk lean mass (3.2%, 0.26 kg). Additionally the mean CV of the scanner during the testing period for the rugby players in this study was 0.37%. Players then lay in a supine position on the DXA scanner bed and were positioned within the scanning area with arms by the side of the body, with the palmer surface of the hand facing and orientated toward the *vastus lateralis* muscle, fingers were pointed and toes plantar flexed to ensure standard positioning. Positioning a foam block between the palmer surfaces of the hand ensured even spacing and the lateral aspect of the thigh and participants were instructed to remain in position until otherwise instructed. Duration of the scan was ~180 s. The scans were analyzed automatically by the software but the operator subsequently confirmed regions of interest. In the present study the percentage of adipose tissue is reported as sub-total, i.e. whole body minus the head to provide stronger associations and reduced measurement error than with DXA defined total (whole body) adiposity, as previously used by Doran et al. (2014). Values were obtained for total mass (kg), lean mass (kg), fat mass (kg) and per cent body fat (%) data. Assessing body composition of team sport players using DXA has previously been validated by Bilsborough et al (2014).

Statistical Analyses

All data are expressed as mean (\pm SD) [range]. Differences between positional groups were compared using a one-way ANOVA with LSD (Least Significant Difference) *post-hoc*. Significance was set as $P < 0.05$ and all statistical analysis was conducted using SPSS v20 for Windows (IBM, New York, NY, USA). Effect sizes were calculated as the difference between the means divided by the pooled standard deviation, with the following quantitative criteria for effect sizes used to explain the practical significance of the findings: trivial <0.2 , small 0.21-0.6, moderate 0.61-1.2, large 1.21-1.99, and very large ≥ 2.0 (Hopkins, 2006).

1 **Results**

2 The physical and anthropometric characteristics of 112 elite European Super League players by position can
3 be seen in Tables 1 and 2.

4 **Height**

5 There was a main effect of player position on height ($F_{5,108} = 14.07$, $P < 0.0005$), with *post-hoc* analyses
6 revealing *small to large* differences between positional groups. The Fullback and Wingers were shorter than
7 Centres ($P = 0.019$; effect size = -0.77), Props ($P < 0.0005$; effect size = -1.20) and Back Row Forwards ($P =$
8 0.01; effect size = -0.96), but taller than Halfbacks ($P = 0.015$; effect size = 0.65) and Hookers ($P = 0.012$;
9 effect size = 0.96). Centres were taller than Halfbacks ($P < 0.0005$; effect size = 1.33) and Hookers (P
10 < 0.0005 ; effect size = 1.77), but similar to Props ($P = 0.458$; effect size = -0.29) and Back Row Forwards (P
11 $= 0.846$; effect size = -0.08). Halfbacks were shorter than Props ($P < 0.0005$; effect size = -1.77) and Back
12 Row Forwards ($P < 0.0005$; effect size = -1.56), but similar in height to Hookers ($P = 0.671$; effects size =
13 0.14).

14

15 *****Table 1 near here*****

16 **Total Mass**

17 There was a main effect of player position on total mass ($F_{5,108} = 20.74$, $P < 0.0005$), with *post-hoc* analyses
18 revealing *small to very large* differences between positional groups. While Fullback and Wingers were not
19 different to Hookers ($P = 0.44$; effect size = 0.25) or Centres ($P = 0.062$; effect size = -0.71) they had lower
20 total mass than Props ($P < 0.0005$; effect size = -1.95) and Back Row Forwards ($P = 0.001$; effect size = -
21 1.06), but higher total mass than Halfbacks ($P = 0.048$; effect size = 0.59). Centres total mass was not
22 different to Back Row Forwards ($P = 0.448$; effect size = -0.35), but greater than Halfbacks ($P = 0.001$;
23 effect size = 1.38) and Hookers ($P = 0.025$; effect size = 0.92), and lower than Props ($P < 0.0005$; effect size
24 $= -1.45$). Halfbacks total mass was lower than Props ($P < 0.0005$; effect size = -2.56) and Back Row
25 Forwards ($P < 0.0005$; effect size = -1.78), but not different than Hookers ($P = 0.374$; effect size = -0.30).

1 The total mass of the Props was higher than Hookers ($P < 0.0005$; effect size = 2.05) and Back Row
 2 Forwards ($P < 0.0005$; effect size = 1.24).

3 **Lean Mass**

4 There was a main effect of player position on lean mass ($F_{5,108} = 16.58$, $P < 0.0005$) with *post-hoc* analyses
 5 revealing *small* to *very large* differences between positional groups. Fullbacks and Wingers possessed lower
 6 lean mass than Centres ($P = 0.046$; effects size = -0.71) and Back Row Forwards ($P = 0.008$; effect size = -
 7 0.77), although their lean mass was greater than Halfbacks ($P = 0.033$; effect size = 0.61). There was no
 8 significant difference in lean mass between Fullbacks and Wingers and the Hookers ($P = 0.087$; effect size =
 9 0.58).

10 Centres had higher lean mass than Halfbacks ($P < 0.0005$; effect size = 1.44) and Hookers ($P < 0.0005$); effect
 11 size = 1.42), but had lower lean mass than Props ($P = 0.007$; effect size = -1.01). There was no difference in
 12 lean mass between Centres and Back Row Forwards ($P = 0.944$; effects size = -0.02). Halfbacks had similar
 13 lean mass values to Hookers ($P = 0.904$; effect size = -0.03), but possessed lower lean mass than Props (P
 14 < 0.0005 ; effect size = -2.26) and Back Row Forwards ($P < 0.0005$; effect size = -1.54).

15 **Fat Mass**

16 There was a main effect of player position on fat mass ($F_{5,108} = 9.93$, $P < 0.0005$), with *post-hoc* analyses
 17 revealing *small* to *large* differences between positional groups. Fullbacks and Wingers had lower fat mass
 18 than Props ($P < 0.0005$; effect size = -1.41) and Back Row Forwards ($P = 0.01$; effect size = -1.25), but were
 19 not different to Centres ($P = 0.571$; effect size = -0.33), Halfbacks ($P = 0.456$; effect size = 0.28) and
 20 Hookers ($P = 0.237$; effect size = -0.44). Centres had lower fat mass than Props ($P < 0.0005$; effect size = -
 21 1.19), but were similar to Halfbacks ($P = 0.252$; effect size = 0.53), Hookers ($P = 0.597$; effect size = -0.21)
 22 and Back Row Forwards ($P = 0.143$; effect size = -0.80). Halfbacks had lower fat mass than Props (P
 23 < 0.0005 ; effect size = -1.47) and Back Row Forwards ($P = 0.002$; effect size = -1.24) but were not different
 24 to Hookers ($P = 0.084$; effect size = -0.59).

1 **Body Fat Percentage**

2 There was a main effect of player position on body fat percentage ($F_{5,108} = 50.7$, $P < 0.0005$), with *post-hoc*
3 analyses revealing *small* to *moderate* differences between positional groups. Fullbacks and Wingers had a
4 lower body fat percentage than Props ($P < 0.0005$; effect size = -1.06) and Back Row Forwards ($P = 0.038$;
5 effect size = -0.86), but were not different to Centres ($P = 0.97$; effect size = 0.0), Halfbacks ($P = 0.686$;
6 effect size = 0.14) and Hookers ($P = 0.088$; effect size = -0.61). While Centres had lower body fat percentage
7 than Props ($P = 0.002$; effect size = -1.03), they were not different to Halfbacks ($P = 0.715$; effect size =
8 0.14), Hookers ($P = 0.153$; effect size = -0.59) or Back Row Forwards ($P = 0.109$; effect size = -0.80).
9 Halfbacks were similar to Hookers ($P = 0.052$; effect size = -0.63), but had lower body fat percentage than
10 Props ($P < 0.0005$; effect size = -1.03) and Back Row Forwards ($P = 0.02$ effect size = -0.78).

11 *****Table 2 near here*****

12

1 Discussion

2 The primary aim of the present study was to characterize the anthropometric characteristics (total mass, lean
3 mass, fat mass and percentage body fat) of elite European Super League players using DXA scan technology
4 in an attempt to identify position specific profiles. To this end we recruited and tested 112 players from five
5 different Super League first team squads (all with different nutrition and strength coaches) to ensure a
6 heterogeneous player group. We report *small* to *very large* anthropometric differences between playing
7 positions and, perhaps more importantly, there was considerable variation in anthropometric characteristics
8 within playing positions. These data therefore provide a base for talent identification and player profiling,
9 although caution must be taken given the prevalence for deviations from the standard position profile.

10 As expected, differences in body fat (percentage and total) between the Outside Backs (i.e. Fullback,
11 Wingers, Centres) and Forwards (i.e. Props, Back Row) were typically *small* to *large* in magnitude, with
12 Prop forwards showing larger body fat values than all other playing groups.. These findings reaffirm
13 previous data using skinfolds that show forward players being the heaviest and with the greatest body fat
14 (Cheng et al., 2013; Gabbett, 2002; Morgan & Callister, 2011; Till, Cobley, O'Hara, Chapman, & Cooke,
15 2013). The additional fat mass in the Props likely represents the unique positional demands of this group of
16 players, who are required to withstand high speed physical collision on a more regular basis than the other
17 groups (Twist et al., 2012). Moreover, the detrimental effects of higher body fat on athletic performance in
18 the Props might be compensated by the fact that they have less game time than the other groups through
19 tactical substitutions (Gabbett et al., 2012; Waldron, Highton, Daniels, & Twist, 2013).

20 The present data also confirms the large intra-position variation in body composition (Cheng et al., 2013;
21 Gabbett, 2006). For example, whilst the mean percentage body fat of the Hookers was ~14%, the maximum
22 percentage body fat was as high as 23% and the lowest as little as 10%. Whilst one could argue that reducing
23 body fat might be beneficial to performance in players that exhibit higher than average values (i.e. an
24 improved power-to-mass ratio), extra fat mass might be advantageous in collisions. However, this suggestion
25 remains speculative and requires further investigation. These data also suggest that an ideal body fat value
26 for elite rugby league players within a positional group does not exist. Accordingly, the assessment of body

fat might be best employed as a monitoring tool to track individual changes due to nutritional or training interventions, rather than as a selection tool. These data also suggest that body fat assessment in rugby league should be used as a confirmatory tool rather than diagnostic, and that coaches should be encouraged to assess the whole physiological profile.

One advantage of assessing body composition using DXA is that lean mass can also be calculated. As anticipated, *small to very large* position specific differences were observed in the present study with the Prop Forwards demonstrating the greatest lean mass and the Halfbacks the lowest. However, as with body fat, there was again large intra-position variation with as much as a 35 kg difference in lean mass within some playing positions. Such a range in lean body mass makes a ‘typical’ or ‘ideal’ profile difficult to establish and might reflect the differing playing styles that can exist within positional groups. For example, some Prop Forwards are often used as ‘impact players’ with their on field time controlled through tactical substitutions (Waldron et al., 2013), whereas other players within the same position often play substantially more minutes and as such might not be able to carry the same absolute mass. It could be argued that this is somewhat unique to rugby league where other team sports (e.g. football) demonstrate a more homogenous anthropometric profile (Iga, Scott, George, & Drust, 2014). Such findings again suggest that anthropometry cannot be used on its own for player selection and should always be viewed alongside other key performance indicators.

Interestingly, we observed similarities in anthropometric profiles between several positional groups. With the exception of the Hookers and Halfbacks the mean height of the playing groups were very similar. These data might represent the fact that in the modern game all players are involved in high-speed physical collisions and are expected to carry the ball aggressively and be strong in defence. Therefore, there are fewer opportunities for the smaller player to be competitive in the modern game. Similarities in most anthropometric characteristics of Centres and Back Row Forwards perhaps reflect the modern game and the need for players to be interchangeable in these two positions. Similarly, the recent trend for coaches to use ball-playing Halfbacks in the Hooker position to ensure dynamic play and ball distribution around the ruck is supported by the similar anthropometric traits between these two positional groups. The only truly unique positional group identified in the present study was that of the Prop Forwards who were consistently taller,

possessed more lean mass, more body fat and more total mass than all other playing groups. Taken together, the current data reflect the modern game of rugby league where every player must tackle, make large impact collisions with the ball in hand whilst remaining fast and agile. To enable versatility within a squad, coaches would seem to require the ‘complete’ player with the ability to play in several positions rather than focusing on one particular skill set. It would be interesting to establish if the reasons that players migrate to a given position (especially Prop Forward) is due to a genetic predisposition for these physical characteristics or due to a lifetime of training to play this role. Such genetic studies are now possible and provide an exciting opportunity for future research.

Whilst this study provides novel data for the literature, inherent limitations exist as a direct consequence of collecting data on elite full-time professional athletes. Although players were asked to arrive to the laboratory euhydrated, no formal hydration assessment was performed. Additionally, dietary intake was not controlled for 24 h before DXA assessment and this might have influenced results through food intake affecting lean mass estimates (Nana et al., 2014). Players were only measured once at the start of pre-season or at the beginning of the season and it is well documented that anthropometric profiles might change throughout the season (Georgeson et al., 2012; Harley et al., 2011). Finally, future research should be performed on a larger sample of Super League clubs and players in an attempt to establish if anthropometric profiles differ between playing standards. For example, comparing international to non-international players, or players from top four to bottom four clubs.

Conclusion

In conclusion, the present study has for the first time assessed the body composition of elite European Super League players from more than one club using DXA scan technology. We report that there are significant differences between player positions, especially separating the Prop Forwards from the other positional groups. Perhaps most importantly however, there are large differences within playing positions and therefore it is not possible to identify an ideal position specific anthropometric profile. Using the first large scale analysis on the anthropometric profile of elite Super League rugby players, these data can be used by

coaching staff working with senior and junior players to inform individualized player training and nutrition strategies.

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Table 1. Mean (\pm SD) [range] for age and height of Professional rugby league players by position. Differing letters denote significant difference from other.

Position	Fullback and Winger (<i>n</i> = 24)	Centre (<i>n</i> = 10)	Halfbacks (<i>n</i> = 18)	Hooker (<i>n</i> = 10)	Prop (<i>n</i> = 24)	Back Row Forward (<i>n</i> = 26)
Age (y)	25 (\pm 5) [16-35]	24 (\pm 5) [18-34]	25 (\pm 6) [16-37]	26 (\pm 6) [18-33]	24 (\pm 5) [18-37]	24 (\pm 5) [19-34]
Height (cm)	181.1 (\pm 5.5) ^a [171-191]	185.4 (\pm 5.7) ^b [176-197]	177.1 (\pm 6.7) ^c [165-192]	176.3 (\pm 4.5) ^c [170-185]	186.8 (\pm 3.9) ^b [180-194]	185.8 (\pm 4.2) ^b [178-198]

* Halfbacks include the stand-off and scrum-half positions combined. Back Row Forward includes the second row and lock forwards combined.

Table 2. Mean (\pm SD) [range] total mass, lean mass, fat mass and body fat percentage values of Professional rugby league players by position groups. Differing letters denote significant difference from other.

Position	Fullback and Winger (<i>n</i> = 24)	Centre (<i>n</i> = 10)	Halfbacks (<i>n</i> = 18)	Hooker (<i>n</i> = 10)	Prop (<i>n</i> = 24)	Back Row Forward (<i>n</i> = 26)
Total Mass (kg)	85.9 (\pm 8.2) ^a [71-99]	91.2 (\pm 6.6) ^{ab} [79-103]	81.1 (\pm 8.0) ^c [65-91]	83.7 (\pm 9.5) ^{ac} [69-98]	102.2 (\pm 8.5) ^d [89-128]	93.3 (\pm 5.5) ^b [85-106]
Lean Mass (kg)	71.9 (\pm 6.6) ^{ac} [61-82]	76.1 (\pm 5.1) ^b [66-86]	68.0 (\pm 6.1) ^c [55-78]	68.2 (\pm 6) ^c [60-77]	81.8 (\pm 6.1) ^d [71-99]	76.2 (\pm 4.4) ^b [69-86]
Fat Mass (kg)	10.9 (\pm 2.2) ^a [7-17]	11.7 (\pm 2.6) ^{ac} [8-16]	10.1 (\pm 3.4) ^{ac} [6-16]	12.5 (\pm 4.6) ^{ac} [7-22]	16.8 (\pm 5.5) ^d [10-35]	13.6 (\pm 2.1) ^c [9-18]
Body Fat (%)	12.7 (\pm 2.1) ^a [9-17]	12.7 (\pm 2.4) ^{ac} [9-17]	12.3 (\pm 3.4) ^{ac} [8-19]	14.6 (\pm 3.9) ^{ac} [10-23]	16.3 (\pm 4.3) ^d [11-27]	14.5 (\pm 2.1) ^c [10-18]

* Halfbacks include the stand-off and scrum-half positions combined. Back Row Forward includes the second row and lock forwards combined.